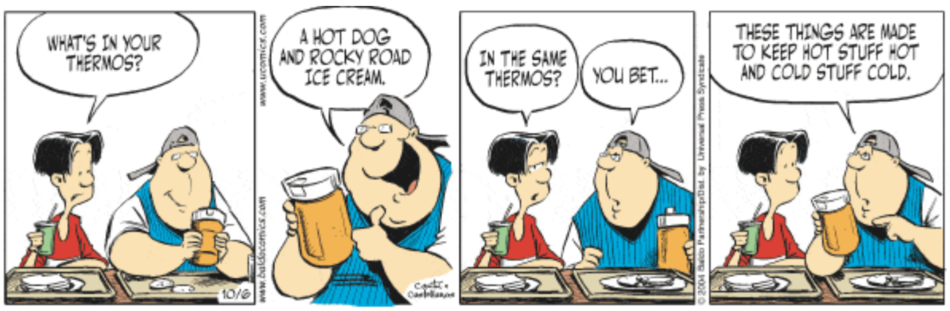
December 7, 2016 Physics 131 Prof. E. F. Redish

- **<u>Theme Music:</u> Ruth Laredo (played by)**
  Ritual Dance of Fire (Albenez)
- **<u>Cartoon:</u> Cantu & Castellanos**
  Baldo



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The Equation of the Day

Conservation of mechanical and thermal energy

$$\left(K_A + U_A^{\text{int}}\right) + \left(K_B + U_B^{\text{int}}\right) + U_{AB}^{PE} = \text{constant}$$

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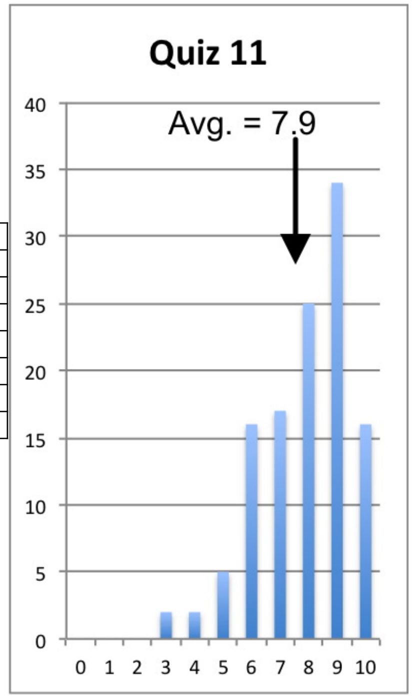
Quiz 11

	1		2				3
B=D>C>A	**51%**	F	**63%**	16%	15%	A	8%
B=D>A>C	20%	0	7%	**71%**	5%	C	33%
B=D>C>A=0	9%	C	30%	10%	**79%**	AC	**45%**
B=D>C=0>A	6%					BC	6%
B>A=0>C>D	1%					CD	3%
B=D=0>C>A	1%					AD	3%
B=D>A=0>C	2%						



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Foothold ideas: 1

- Temperature is a measure of how hot or cold something is. (We have a natural physical sense of hot and cold.)
- When two objects are left in contact for long enough they come to the same temperature.
- When two objects of the same material but different temperatures are put together they reach an average, weighted by the fraction of the total mass.
- The mechanism responsible for the above rule is that the same thermal energy is transferred from one object to the other: Q proportional to $m\Delta T$.

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Foothold ideas: 2

- When two objects of different materials and different temperatures are put together they come to a common temperature, but it is not obtained by the simple rule.
- Each object translates thermal energy into temperature in its own way. This is specified by a density-like quantity, *c*, the specific heat.
- The heat capacity of an object is $C = mc$.
- When two objects of different material and different temperatures are put together they reach an average, weighted by the fraction of the total heat capacity.
- When heat is absorbed or emitted by an object

$$Q = \pm mc\Delta T$$

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Foothold ideas: Non-conservative forces

- Work-energy theorem: $\Delta(\tfrac{1}{2}mv^2) = \vec{F}^{net} \cdot \Delta\vec{r}$
- For conservative forces (non-resistive), the work done by the force can be represented as a Potential Energy: $\vec{F} \cdot \Delta\vec{r} = -\Delta U$
- So when there are non-conservative forces, the work-energy theorem becomes:

$$\Delta(\tfrac{1}{2}mv^2 + U) = \vec{F}^{net}_{non-cons} \cdot \Delta\vec{r}$$

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Where does the energy go?

- We were able to define a kind of energy for conservative forces. Can we define one for non-conservative forces?

$$\Delta(\tfrac{1}{2}mv^2 + U) = \vec{F}^{net}_{non-cons} \cdot \Delta\vec{r}$$

- The answer lies in finding kinetic and potential energies at other scales that we can't see directly – either because of many random motions or quantum mechanics.

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Losing (or gaining) mechanical energy

- Resistive forces divert energy from coherent kinetic and potential energies of macroscopic objects to the kinetic and potential energies of microscopic atoms and molecules.
- Internal kinetic and potential energies of atoms and molecules can be exchanged with the kinetic and potential energies of the atoms and molecules themselves, and even with macroscopic objects.

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Foothold ideas: Kinds of internal energy

- *Thermal Energy* – Energy of random motion of the atoms and molecules of an object. Can be kinetic or potential (for solids and liquids).
- (*Chemical Energy* – Internal kinetic and potential energy of electrons inside an atom.)*

* We'll bring this in to 132

Foothold ideas: Energy conservation with thermal energy

- Consider the collision of two objects so all external forces are balanced.
- If there are no resistive forces, mechanical energy is conserved.

$$K_A + K_B + U_{AB}^{PE} = \text{constant}$$

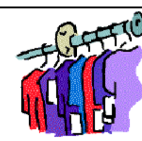
- If there are resistive forces, energy can be transferred from the mechanical energy of the objects to their internal (thermal) energy.

$$\left(K_A + U_A^{\text{int}}\right) + \left(K_B + U_B^{\text{int}}\right) + U_{AB}^{PE} = \text{constant}$$

Reading questions

- Why do objects have a specific heat, even if they are made of the same stuff? (ex. diamonds and graphite)
- Where is the heat stored in the object?
- I still don't understand the difference between specific heat (c) and heat capacity (C)? / Is heat capacity an intensive property like specific heat?
- Why is volume not an important factor for heat, wouldn't the energy in heat be different in different volume objects?
- Is an object absorbing heat considered an endothermic reaction?
- Can specific heat ever vary or change for the same object?
- Are there ways in which we can use the idea of kinetic and potential energy to calculate the heat capacity of a system?
- If you are given the temperature in Celsius, and the c value in Kelvin, do you need to convert to solve these problems?

Real-World Intuition 1: Reconsidered



- If we have a cup of hot water and a cup of cold water and we put them aside for a while, what will happen to them?

- If you touch the cloth part of your chair and the metal part, which feels warmer?